INDOOR AIR QUALITY ASSESSMENT

Mary A. Dryden Memorial Elementary School Annex
190 Surrey Road
Springfield, Massachusetts

Prepared by:
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Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Judy Dean, Western Massachusetts American Lung Association, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA), was asked to provide assistance and consultation regarding indoor air quality at the Mary A. Dryden Elementary School (MDES), 190 Surrey Road, Springfield, Massachusetts. On March 7, 2003, a visit was made to this school by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment. Mr. Feeney was accompanied by Ms. Dean during the assessment. Reports of inadequate ventilation, odors, lack of temperature control and other indoor air quality issues prompted the assessment.

The school consists of two separate buildings: the original building and the annex. The annex (MDESA) is a two room, single story structure, built in 1953. The MDESA contains two general classrooms and restrooms. Windows are openable. The MDES is a one-story red brick building and is the subject of a separate report.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The school complex houses kindergarten through fifth grades with a student population of approximately 350 and a staff of approximately 30. The MDESA contains a special needs class with approximately 5 students and 4 staff. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were below 800 parts per million parts of air (ppm) in both areas surveyed indicating adequate air exchange. At the time of the assessment, the ventilation system in both classrooms was deactivated, which would limit the introduction of fresh air. Due to the configuration and condition of the ventilation system, carbon dioxide levels in the building would be expected to increase over comfort levels during winter months when windows are closed, pariticularly if the building population increases.

Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Picture 1). Univents are designed to draw air from outdoors through a fresh air intake located on the exterior wall of the building and return air through an air intake located at the base of each unit (see Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located on the front of the unit. Univents were found deactivated, which prevents a continuous source of outside air to provide ventilation. Obstructions to airflow, such as beanbag chairs in front of univent return vents were noted (see Picture 1). In order for univents to provide fresh air as designed, univent air diffusers and return vents must remain free of obstructions. Importantly, these units must be activated and allowed to operate.

The univent in classroom 17 was opened and examined. Airflow into the univent is controlled by a pendulum louver (see Picture 2). The position of the louver determines the amount of fresh to return air from the classroom. The louver in Picture 2 is fixed in the closed position, preventing fresh air intake by the univent. Assuming that this univent is representative of others, the ventilation system is not able to draw fresh air from outdoors. The sole means for introducing fresh air into the building is through opening windows.

A mechanical exhaust vent exists in each classroom, consisting of a grill installed in a metal duct. The metal ductwork is connected to recently installed rooftop exhaust motors (see Picture 3). Both classroom exhaust vents were operating during the assessment.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix I.

Temperature readings (70^{o} F to 72^{o} F) were within the BEHA recommended comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. Temperature control is difficult in an old building with abandoned or nonfunctioning ventilation systems. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in classrooms was 15 to 17 percent, which was below BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. The sensation of dryness and irritation is common in a low relative humidity environment. Humidity is more difficult to control during the winter heating season. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

The design of the roof makes it prone to developing water leaks. The MDESA has a flat roof covered with a rubber membrane. No drains appear to have been installed in the roof, which seems to have a slight pitch. Water can accumulate on the roof, particularly with snow cover. Once a certain amount of water has pooled, the excess spills over the roof edge into a gutter system. The accumulation of water on the roof can lead to premature wear and create leaks in seams with the freezing and thawing cycle during cold weather.

Water-damaged ceiling tiles were observed, which indicates a current or historic water penetration problem. Tiles appear to be directly adhered to the ceiling. Replacement of the ceiling tiles is difficult, since their removal appears to necessitate the destruction of the tile (see Picture 4), which can result in the aerosolization of particulates. Water-damaged ceiling tiles may provide a medium for mold growth and should be replaced after a water leak is discovered.

Other Concerns

Univent heat control is supplemented in classrooms by cabinet radiators.

Walls in which univents are installed have spaces and holes within the air handling cabinet (see Picture 5). Of note is the heavy accumulation of dust around the edges of each hole, indicating unfiltered air passage. The existence of these holes provides for air to by-pass the installed filters, resulting in aerosolization of materials (e.g. dust, odors) from the classrooms. In addition, spaces exist around heating pipes that penetrate through the floor (see Picture 6). Spaces of this nature can result in the univent drawing air and debris from the wall cavity or crawl space and distributing these materials to the interior of the building.

The interiors of both univents and radiators were examined and were found accumulated with dirt, dust and debris (see Picture 6). Univents have filters that provide minimal filtration of respirable dust. In order to avoid serving as a source of aerosolized particulates, the air handling sections of the univents should be regularly cleaned. In order to decrease aerosolized particulates, disposable filters with a high dust spot efficiency should be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced by the unit due to increased resistance (called pressure drop). Prior to any increase of filtration, each univent should be evaluated by a ventilation engineer to ascertain whether they can maintain function with higher efficiency filters.

In an effort to reduce noise from sliding chairs, tennis balls have been sliced open and placed on table legs. Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and to off-gas TVOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix II (NIOSH, 1998).

Conclusions/Recommendations

The conditions noted at the MDESA raise a number of indoor air quality issues. The combination of poor maintenance of the HVAC system and production of latex dust, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons a two-phase approach is required, consisting of **short-term** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns.

The following **short-term** measures should be considered for implementation:

1. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the restoration of univent fresh air control dampers throughout the school.
2. Remove all blockages from univents to ensure adequate airflow. Clean interiors of univents regularly.
3. To maximize air exchange, the BEHA recommends that the ventilation system operate continuously during periods of school occupancy independent of classroom thermostat control.
4. Once both the fresh air supply and the exhaust ventilation are functioning, the ventilation system should be balanced.
5. Supplement airflow in classrooms by using openable windows to control for comfort. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
6. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

7. Discontinue the use of tennis balls on chairs to prevent latex dust generation.
8. In order to maintain a good indoor air quality environment on the building, consideration should be given to adopting the US EPA document, "Tools for Schools", which can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.
9. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

The following **long-term measures** should be considered:

1. Water-damaged ceiling tiles should be replaced. These ceiling tiles can be a source of microbial growth and should be removed. Sources of water leaks (e.g. window frames and roof) should be identified and repaired. Examine the non-porous surface beneath the removed ceiling tiles and disinfect with an appropriate antimicrobial.

References

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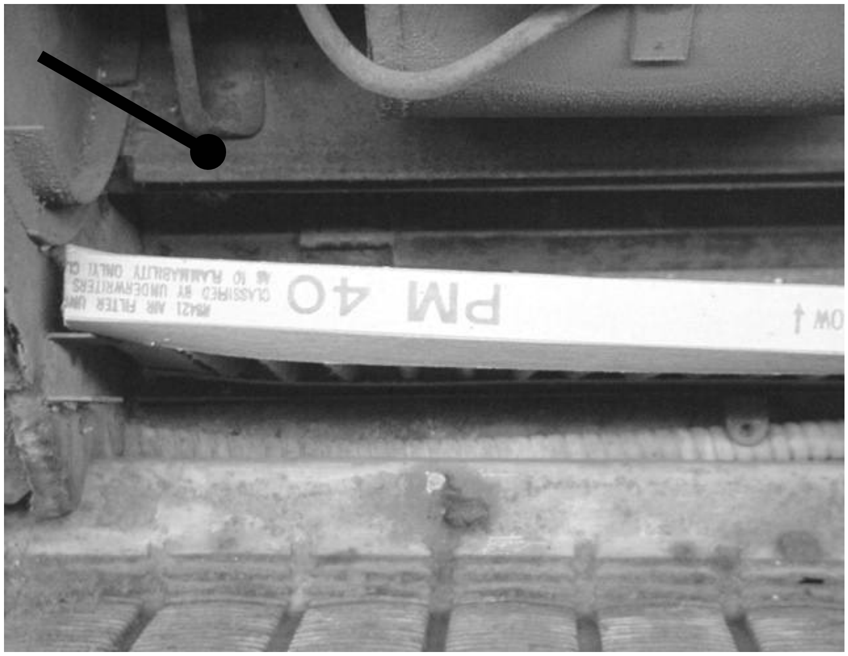
Picture 1

Univent, Note Bean Bag Chairs Blocking Univent Return Vent

Picture 2



Pendulum Louver in Univent

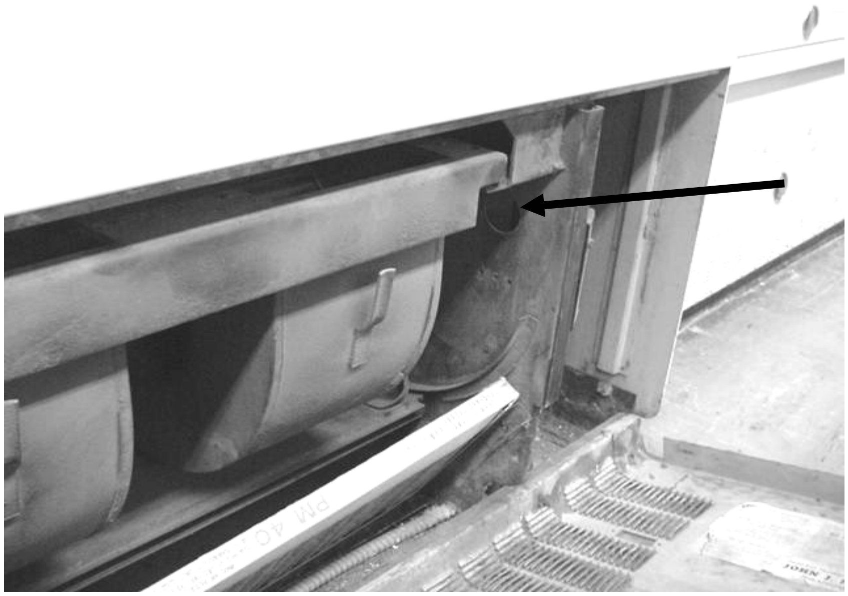
Picture 3

Rooftop Exhaust Vents

Picture 4

Water Damage Ceiling Tiles

Picture 5



Hole in Univent Cabinet

Picture 6

Hole in Floor for Heating Pipe, Note Dust and Debris Accumulation Inside Univent

TABLE 1

Indoor Air Test Results – Dryden Elementary School March 7, 2003

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	381	35	22					
Room 13	645	72	15	9	Y	Y	Y	CT 10 +, window air conditioner Tennis balls
Room 14	672	70	17	0	Y	Y	Y	Window air conditioner
Main Office	883							
Room 18	1156	68	19	9	Y	N	N	

- **ppm = parts per million parts of air**
  CT = water damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%